Irish Fisheries Investigations No. 23 2012

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ISSN 1649 0037

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Acknowledgments

We would like to express our thanks and gratitude to Peter Mogan (Captain) and crew of the FV *Felucca* for their good will and professionalism during the survey. The help and knowledge imparted during the survey was invaluable in helping to understand the behaviour of this species. The survey was funded by the Killybegs Fishermen's Associated (KFO) and Fisheries Science Services (FSS).

Photography credits

Photographs throughout the publication have been provided by Ciaran O'Donnell ©, Marine Institute.

Funding

The survey was funded by the Killybegs Fishermen's Associated (KFO) and Fisheries Science Services (FSS).

Abstract

The Boarfish (*Capros aper*, Linnaeus) is a relatively small deep bodied fish growing up to 23 cm in total length. Typically reddish in colour with large eyes and a highly protrusible mouth boarfish are known to inhabit shallow shelf seas to shelf slopes from 40-600 m. Boarfish are a mesopelagic shoaling species distributed in the eastern Atlantic from Norway to Senegal including the Mediterranean.

Exploratory fishing for boarfish by Irish vessels began in the later 1980s when commercial quantities were encountered during the spring horse mackerel (*Trachurus* trachurus) and mackerel (*Scrombrus scomber*) fishery in northern Biscay. During the early 2000s the Irish landings were relatively small (<700 t per yr) and it was not until 2006 that a directed fishery developed in earnest. Landings peaked in 2010 at over 137,000 t prior to the introduction of TAC control and interim management plan.

This survey represents the first dedicated exploratory acoustic survey for boarfish (*Capros aper*) undertaken along the western seaboard of Ireland. The survey was timed to coincide with peak spawning time as determined from histological analysis of commercial catch samples. Area coverage was based on the distribution of catches from the IBTS survey time series and from catch data from the pelagic fleet targeting boarfish since 2005. In total 3,160 nmi (nautical miles) of cruise track was undertaken by the MFV *Felucca*, over 32 transects relating to an area coverage of over 89,500 nmi^2. Coverage extended from the 50 m contour to the shelf slope (250 m). Transect spacing was set at 15 nmi throughout to make best use of the time available and the large geographical area to be covered. The results presented here are a composite of data collected during this survey and on the northwest herring survey (RV *Celtic Explorer*). Both surveys were timed to link up and were carried out over 33 days from north (59°N) to south (47°30'N).

Acoustic data were collected using a Simrad EK 60 scientific echosounder via a Simrad ES-38B (38 KHz) split-beam transducer which was mounted within a towbody. This configuration was calibrated on the survey vessel prior to departure.

An age length key (ALK) compiled primarily from commercial samples collected during 2010 was applied during the analysis of survey data. Age distribution indicate that the stock was dominated by the following age classes in terms of abundance: 6, 7, 20+ and 9 year old fish and 20+, 9, 7 and 10 years in terms of biomass respectively.

Immature fish from 0-2 years were poorly represented in survey catches and this is consistent with a spawning movement of mature stock away from feeding grounds on the shelf. During the survey boarfish shoals were primarily distributed along the shelf edge occurring as aggregations actively spawning or in a state of near readiness to spawn. As a result the abundance estimate is almost exclusively composed of mature individuals (>99%) which is in contrast to the primarily on-shelf distribution of commercial catches.

The biomass and abundance estimates presented here were calculated using a modelled TS-length relationship, from as yet unpublished data for boarfish and applied retrospectively to acoustic data.

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1 Introduction

The Boarfish (*Capros aper*, Linnaeus) is a relatively small deep bodied fish growing up to 23 cm in total length. This species shows a high degree of lateral compression and has robust dorsal and pectoral spines. Typically reddish in colour with large eyes and a highly protrusible mouth boarfish are known to inhabit shallow shelf seas to shelf slopes from 40-600 m (Whitehead et al., 1986; Heemstra, 1999). Boarfish are a mesopelagic shoaling species distributed in the eastern Atlantic from Norway to Senegal including the Mediterranean. Boarfish are found widely distributed throughout their range and are often associated with the shelf edge and areas of high productivity such as on-shelf Banks (Tidd and Warnes, 2006).

From the early 1970s onwards the abundance of boarfish (*Capros aper*) was seen to increase exponentially along the western seaboard and Bay of Biscay and distribution increasingly spread northwards (Blanchard and Vandermeirsch, 2005). At the same time, boarfish were caught in increasing quantities in both pelagic and demersal fisheries. This in turn resulted in damaged to more commercially valuable species in the net due to the robust boarfish dorsal spines. Exploratory fishing for boarfish by Irish vessels began in the later 1980s when commercial quantities were encountered during the spring horse mackerel (*Trachurus* trachurus) and mackerel (*Scrombrus scomber*) fishery in northern Biscay. Several landings were made into Ireland for fishmeal during this time but due to logistical problems related to handling (prominent dorsal spines) this species was not favoured by processors. Interest increased again around the mid 1990s when Dutch pelagic vessels landed frozen samples to determine if a market could be developed for human consumption.

During the early 2000s the Irish landings were relatively small (<700 t per yr) and it was not until 2006 that a directed fishery developed in earnest. Fishing was undertaken primarily by vessels from the Castletownbere and Killybegs based RSW fleets (refrigerated seawater vessels) which targeted boarfish from northern Biscay to the southern Celtic Sea. In 2007-08 vessels from Scotland and Denmark also began targeting boarfish in quantity. Irish landings are primarily landed into fishmeal plants in Denmark and the Faroe Islands with increasing amounts being landed in Killybegs. The boarfish fishery bridged an important gap between the short season fisheries for horse mackerel, mackerel and blue whiting (*Micromesistius poutassou*) affectively extending the fishing season for the RSW fleet from late August through to May.

A precautionary interim management plan was adopted in November 2010 covering ICES Divisions VI, VII and VIII and an EU TAC of 33,000 t was set. Of this the Irish allocation for 2011 was 22,000 t. This precautionary TAC was based on 50-75 % of total landings from the period 2007-2009 which peaked at over 83,400 t (2009). Landings in 2010 reached over 137,000 t prior to the introduction of TAC control. In addition to the TAC control, seasonal closures were also implemented; from September 1-October 31 ICES (area VIIg) to protect herring feeding and pre spawning aggregations and from March 15–August 31 where mackerel are frequently encountered as a large bycatch. A catch rule ceiling of 5 % bycatch was also implemented within the fishery where boarfish are taken with other TAC controlled species.

This survey represents the first dedicated exploratory research survey for boarfish (*Capros aper*) undertaken along the western seaboard of Ireland. The commercial fishing vessel the MFV *Felucca,* an active participant in the fishery was equipped with a standard scientific echosounder (Simrad EK 60) and transducer within a towed body. This configuration was calibrated on the survey vessel prior to departure. A consultant biologist from the Killybegs Fisherman's organisation (KFO) and a Marine Institute scientist headed the biological and acoustic research respectively during the cruise.

Data from this survey, in addition to the extensive biological research carried out on this species forms part of a larger program aimed at increasing the knowledge of this species and its abundance outside of the commercial fishery. Data from this survey will be presented for inclusion into the ICES Planning Group meeting for North Atlantic Pelagic Ecosystem Surveys in August 2011 (WGNAPES) and for the ICES assessment Working Group for Widely Distributed Stocks (WGWIDE) also meeting in August 2011.

2 Materials and Methods

2.1 Scientific Personnel

Organisation	Name	Capacity
FSS	Ciaran O'Donnell	Acoustics (SIC)
KFO	Edward Farrell	Biologist
Contractor	Jason Clarke	Biologist
Contractor	John Cunningham	Fisheries Obs.

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives of the survey are listed below:

- Collect integrated and calibrated acoustic data on boarfish (*Capros aper*) aggregations within the pre-determined survey area
- Determine the biomass and abundance of boarfish within the survey area
- Collect biological samples from directed trawling on insonified echotraces to determine age structure and maturity state of survey stock as well as to identify echotrace to species.
- Determine the extent and behaviour of boarfish aggregations within the survey area to aid the design of future surveys
- Dovetail with the RV Celtic Explorer in the northern area to ensure close spatio-temporal alignment and increase effective area coverage

2.2.2 Area of operation

The survey was carried out initially in the Porcupine Bank area before moving to survey the shelf area between 47° 30'N and 53° 30'N from north to south following a pre-determined cruise plan (Figure 1). Area coverage was based on the distribution of catches from the IBTS survey time series and from catch data from the pelagic fleet targeting boarfish since 2005.Timing was planned to coincide with the arrival of the RV *Celtic Explorer* at the top end of the survey area to ensure a continuous, quasi-synoptic, coverage of the combined area.

In total 3,160 nmi (nautical miles) of cruise track was undertaken by the MFV *Felucca* over 32 transects relating to an area coverage of over 89,490 nmi^2. Coverage extended from the 50 m contour to the shelf slope (250 m). Transect spacing was set at 15 nmi throughout to make best use of the time available and the large geographical area to be covered. Elementary sampling distance units (ESDU) of 1 nmi were used during the survey in line with the RV *Celtic Explorer*.

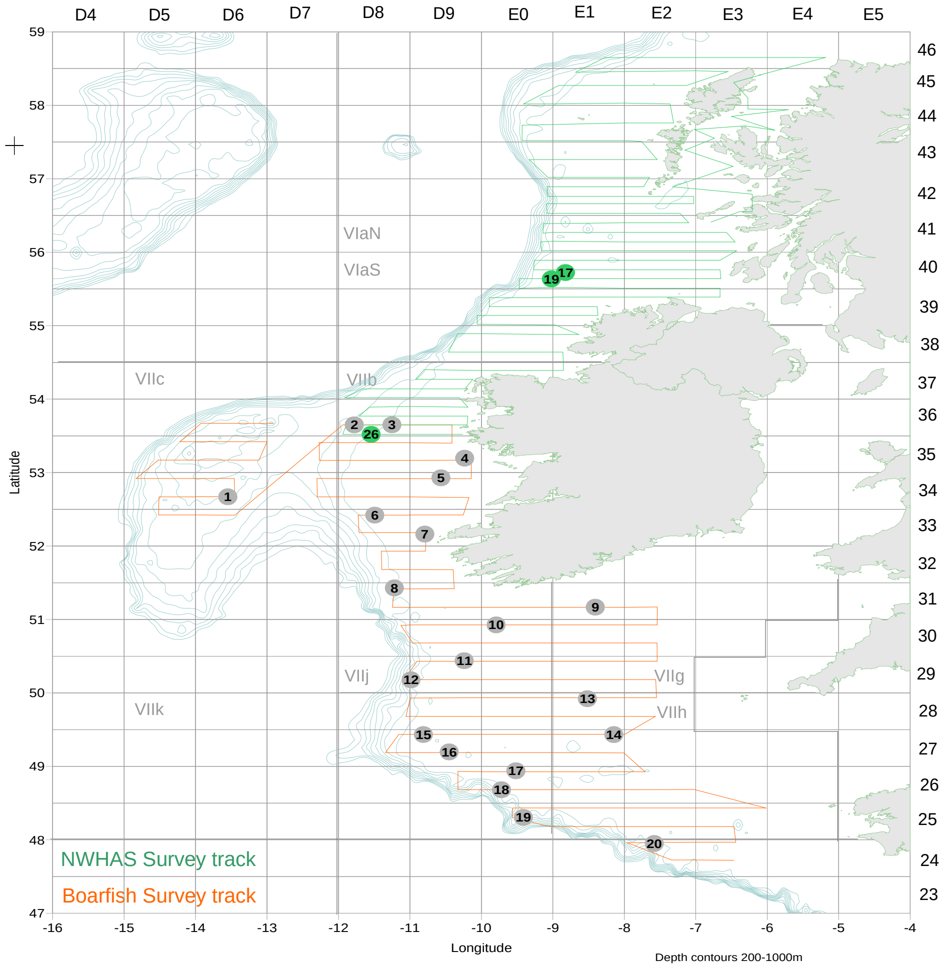


Figure 1. Cruise tracks and positions of hauls containing boarfish for the FV *Felucca* (orange) and RV *Celtic Explorer* (green).

2.3 Equipment and system details and specifications

2.3.1 Acoustic equipment

Equipment settings were determined before the start of the survey and are based on established settings employed on previous (herring) surveys (O'Donnell *et al.,* 2004) and are shown in Table 1.

Acoustic data were collected using a Simrad EK 60 scientific echosounder topside unit. A Simrad ES-38B (38 kHz) split-beam transducer was mounted within a towbody frame and deployed on the port side via a towing boom to a working depth of 2.5-3 m (Appendix 2).

Cruising speed was determined by the weather and the affects on the quality of acoustic data output. The cruising speed was maintained, where possible at 10-11 Kts.

2.3.2 Calibration of acoustic equipment

The EK 60 was calibrated in Killybegs Harbour on 05 July prior to the start of the survey. The calibration was carried out using standard methodology as described by Foote *et al.* (1987) Results of the calibration are presented in Table 1. The calibration was successful and results were in line with those of previous calibrations.

Table 1. Survey settings and calibration report (38 kHz) for the Simrad EK 60 echosounder.

Vessel :	F/V Felucca	Date :	19/6/2010
Echo sounder :	EK60 Tow Body	Locality :	Killybegs
Type of Sphere : CU 64	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) :	16 m

Calibration Version 2.1.0.11

Comments:
05.07.11

Reference Target:			
TS	-33.50 dB	Min. Distance	15.00 m
TS Deviation	5 dB	Max. Distance	25.00 m
Transducer: ES38B Serial No.			
Frequency	38000 Hz	Beamtype	Split
Gain	26.50 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.10 deg	Along. Beam Angle	6.99 deg
Athw. Offset Angle	-0.07 deg	Along. Offset Angl	-0.15 deg
SaCorrection	-0.62 dB	Depth	3.00 m
Transceiver: GPT 38 kHz 009072033933 1 ES38B			
Pulse Duration	1.024 ms	Sample Interval	0.190 m
Power	2000 W	Receiver Bandwidth	2.43 kHz
Sounder Type:			
ER60 Version 2.2.0			
TS Detection:			
Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max. Echolength	180 %
Environment:			
Absorption Coeff.	9.1 dB/km	Sound Velocity	1505.9 m/s
Beam Model results:			
Transducer Gain =	26.21 dB	SaCorrection =	-0.62 dB
Athw. Beam Angle =	7.02 deg	Along. Beam Angle =	6.96 deg
Athw. Offset Angle =	0.07 deg	Along. Offset Angle=	-0.15 deg

Data deviation from beam model:
RMS = 0.11 dB
Max = 0.42 dB No. = 277 Athw. = -2.1 deg Along = 3.7 deg
Min = -0.45 dB No. = 76 Athw. = 1.8 deg Along = 4.8 deg

Data deviation from polynomial model:
RMS = 0.08 dB
Max = 0.37 dB No. = 277 Athw. = -2.1 deg Along = 3.7 deg
Min = -0.28 dB No. = 78 Athw. = -0.4 deg Along = 2.8 deg

Comments :
Flat calm conditions
Wind Force : 5 kn. **Wind Direction :** SW (270 degrees)
Raw Data File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration 05.07.11
Calibration File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration 05.07.12

2.3.3 Acoustic data acquisition

Acoustic data were recorded onto the hard-drive of the processing unit. The “RAW files” were logged via a continuous Ethernet connection as “EK5” files to laptop and a HDD hard drive as a backup. Sonar Data’s Myriax Echoview® Echolog (Version 4.9) live viewer was used to display the echogram during data collection to allow the scientists to scroll through echograms noting the locations and depths of target schools to a log file. A member of the scientific crew monitored the equipment continually. Time and location were recorded for each transect start/end position within each stratum. This log was also used to monitor “off track events” during fishing operations and hydrographic stations.

2.3.4 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Sonar data's Echoview® (V 4.9) post processing software. The scrutiny process involved the allocation of echotraces (schools) to particular species or species mix categories, based on the information from the directed trawl hauls.

The NASC (Nautical Area Scattering Coefficient) values from each boarfish echotrace were allocated to one of 4 categories after scrutiny of the echograms. Categories identified on the basis of echotrace scrutiny were as follows:

1. "Definitely boarfish" echotraces were identified on the basis of captures of boarfish from the fishing trawls which were sampled directly. Based on the directly sampled schools we also characterised echotrace as definitely boarfish which appeared very similar on the echogram i.e. , large marks which showed as very high intensity (red), located high in the water column (day) and as strong circular schools.

2. "Probably boarfish" were attributed to smaller echotraces that had not been fished but which had similar characteristics to "definite" boarfish traces.

3. "Boarfish in a mixture" were attributed to NASC values arising from all fish traces in which boarfish were contained, based on the presence of a proportion of boarfish in the catch or within the nearest trawl haul. Boarfish were often taken during trawling in mixed species layers during the hours of darkness.

4. "Possibly boarfish" were attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite boarfish traces.

This set of categories allowed us to present the biomass estimates in terms of the best estimate (categories 1-3), the minimum estimate (categories 1 + 3), and the maximum estimate (categories 1-4).

The "EK5" files were imported into Echoview for echo post-processing. The echograms were divided into transects and off track events, including trawl hauls and hydrographic stations were excluded. Echo integration was performed on regions which were defined by enclosing selected parts of the echogram that corresponded to one of the four categories above. The echograms were generally analysed and echo-integrals calculated, at a threshold of -70 dB, where necessary heavy backscatter from plankton was filtered out by thresholding at -65 dB.

The allocated echo integrator counts (NASC values) from these categories were used to estimate the boarfish numbers according to the method of Dalen and Nakken (1983).

The following TS-length relationships used were those recommended by the acoustic survey planning group (ICES, 1994):

Herring TS = $20\log_{10}L - 71.2$ dB per individual (L = length in cm)

Sprat TS = $20\log_{10}L - 71.2$ dB per individual (L = length in cm)

Mackerel TS = $20\log_{10}L - 84.9$ dB per individual (L = length in cm)

H. mackerel TS = $20\log_{10}L - 67.5$ dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids TS = $20\log_{10}L - 67.4$ dB per individual (L = length in cm)

For boarfish (*Capros aper*) a species specific TS length relationship was applied based on theoretical swimbladder modelling from as yet unpublished data (Fassler *et al.* in review).

Boarfish TS = $20\log_{10}L - 65.98$ dB per individual (L = length in cm)

2.3.5 Biological sampling

A single pelagic midwater trawl with the dimensions of 296 m in total length (including a 78 m brailer) was used to collect biological samples. The horizontal net spread was approximately 90 m from wing to wing. Mesh size in the wings was 12.8 m through to 2 cm in the cod-end liner used during the survey. The net was fished with a vertical mouth opening of approximately 45 m, which was observed using a cable linked Simrad FS 900 netsonde (200 kHz). The net was fitted with Marport catch sensors to limit the amount of catch taken during surveys trawls.

All components of the catch from the trawl were sorted to species and weight by species recorded; for species other than boarfish, length and weight measurements were taken for 100 individuals per trawl in addition to a 300 fish length frequency sample. Length, weight, sex and maturity data were recorded for individual boarfish in a random 50 fish sample from each trawl haul. In addition a further 100 length/weight and 300 fish length frequency measurements were taken from each haul. Due to the complexity of aging boarfish, no aging was carried out onboard and samples were analysed back in the lab. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

The decision to fish on particular echotraces was based on both the distance from other fishing operations on similar schools, and on the difference between recently observed echotraces and others previously sampled.

2.3.6 Target strength modelling sample collection

As a component of the project biological samples were collected for analysis aimed at developing a species specific target strength (TS) length relationship for this species. The biomass and abundance estimates presented here were calculated using a modelled TS-length relationship, from as yet unpublished data for boarfish and applied retrospectively to acoustic data.

The collection of quality samples for TS modelling was hampered due to the size of the fishing gear used by the vessel. The vessel used a commercial sized boarfish trawl during the surveying (>270 m total length). Hauling on average took around 15mins and was done very quickly and efficiently. Visual inspection was carried out on samples taken from the catch and those that showed the least sign of external damage were selected for freezing.

Samples were frozen down as quickly as possible once retrieved from the trawl deck. Each fish was laid flat on grease proof paper and left untouched for a period in excess of 48 hrs at -19 °C. After this time the fish were carefully removed then dipped in a cold freshwater bath (glazing) before quickly being returned to the freezer. Once glazed, fish were measured and bagged according to length class for ease of identification later on. The number of fish per bag was kept low and bags were then carefully stored within a rigid cardboard box to protect from damage.

2.4 Analysis methods

2.4.1 Abundance estimates

Total abundance, N_T, is given by $\sum_m^{Mark-types} N_{T,m}$, the sum over the total abundance by echotrace category

$$N_{T,m} = \sum_s^{strata} N_{m,s}$$

Suppressing the echotrace category index, m, the stratum abundance is

$$N_s = area_s \sum_l^{transects} \bar{n}_{s,t} l_{s,t} \Big/ \sum_j l_{s,j}$$

,where l is the transect length and $\bar{n}$ is the transect mean abundance n.mi^{-2} which is given by

$$\sum_j^{track \cdot fragments} n_{s,t,j} d_{s,t,j} \Big/ l_{s,t}$$

, where d is the distance of the track fragment and $n_{s,t,j}$ is the mean abundance n.mi^{-2} for the jth track fragment.

Hauls are assigned to echotraces based on actual catches or by means of the nearest haul with a similar echotrace. Trawl data from multiple hauls from one or more strata may be allocated to a single strata during the analysis. The conversion of NASC into mean density was done sing an EDSU (Elementary distance sampling unit) of 1 nmi Haul assigned, $h_{m,s,t,j}$, depends strongly on the echotrace category (m) and since more than one school can be in a track fragment it needs to be specified. Since age and maturity length-keys are to be applied, the basic estimation is mean density by length bins. The $n_{s,t,j}$ is found by summing over the $n_{s,t,j}$.

$$n_{t,j,i} = \frac{NASC_{t,j}}{\bar{\sigma}_{h_{m,t,j}}} p_{i,h_{m,t,j}}$$

, where i indexes length bins, p_i is the proportion of herring in the i^{th} length bin, and is given by

$$\sum_{spe}^{species} \sum_i p_{spe,i} 10^{(a+b\log10(L_{spe,i}))/10}$$

, where $p_{spe,i}$ applies over all species considered in the haul, $L_{spe,i}$ is the length to use for the i^{th} length bin and the data comes from the haul (of combination of hauls) assigned, $h_{m,t,j}$. For non-mix echotrace category, the later simplifies to

$$\sum_i p_{herring,i} 10^{(073+20\log10(L_{herring,i}))/10} .$$

For biomass, a mean weight is also applied to the $n_{t,j,i}$ using the estimated regression relationship, a L_i^b.

For abundance by age and maturity, the abundance by length bin, $n_{t,j,i}$, is averaged over track fragments and then transects to give a strata (and echotrace category) mean. The age and maturity keys are applied to the results.

$V_s = area_s^2 s_s^2 W_s$, where $W_s = \sum_{l}^{transects} {l^2}_{s,t} \big/ (\sum l_{s,j})^2$ and s^2 is the sample variance. The variance for the total is the sum of strata variances.

The total biomass can be obtained directly from the track fragment mean biomass by

$B_T = \sum_{k}^{track\cdot fragment} \overline{n}_k w_k$, where w_k is a factor that takes into account the factors for transect

and strata averaging, i.e., $w_k = \frac{1n.mi}{l_{t_k}} \frac{l_{t_k}}{\sum_{t}^{stratum.s_k} l_{s_k,t}} area_{s_k} = \frac{1}{\sum_{t}^{stratum.s_k} l_{s_k,t}} area_{s_k}$

, where the 1 n.mi is the length of the track fragment. This ignores the echotrace category since that is already accounted for in the $\overline{n}_k$. The $\overline{n}_k w_k$ is the biomass from a track fragment and they can then be used to map the biomass at a fine spatial scale.

Estimates are made for SSB, total abundance and biomass, abundance by age (ring counts), and abundance by age x length bins. A *CV* (based on strata standard error divided by the strata mean) is estimated for SSB, total abundance and biomass, and abundance by age.

3 Results

3.1 Boarfish abundance and distribution

The results presented here are a composite of data collected during this survey and on the northwest herring survey (RV *Celtic Explorer*). Both surveys were timed to link up and were carried out over 33 days from north (59° N) to south (47° 30'N). Both surveys used calibrated echosounders but no inter-vessel acoustic or fishing intercalibration exercise was carried out. Acoustically derived estimates of abundance were compiled for both surveys to provide a picture of boarfish distribution throughout the range covered.

Twenty hauls were carried out during the boarfish survey of which 12 contained boarfish. A further three hauls from the *C. Explorer* survey yielded boarfish which were used during the analysis (Figure 2, Table 2). Combined over 4,500 lengths, 1,600 length/weight measurements were taken in addition to the 600 individual boarfish otiliths which were collected for aging.

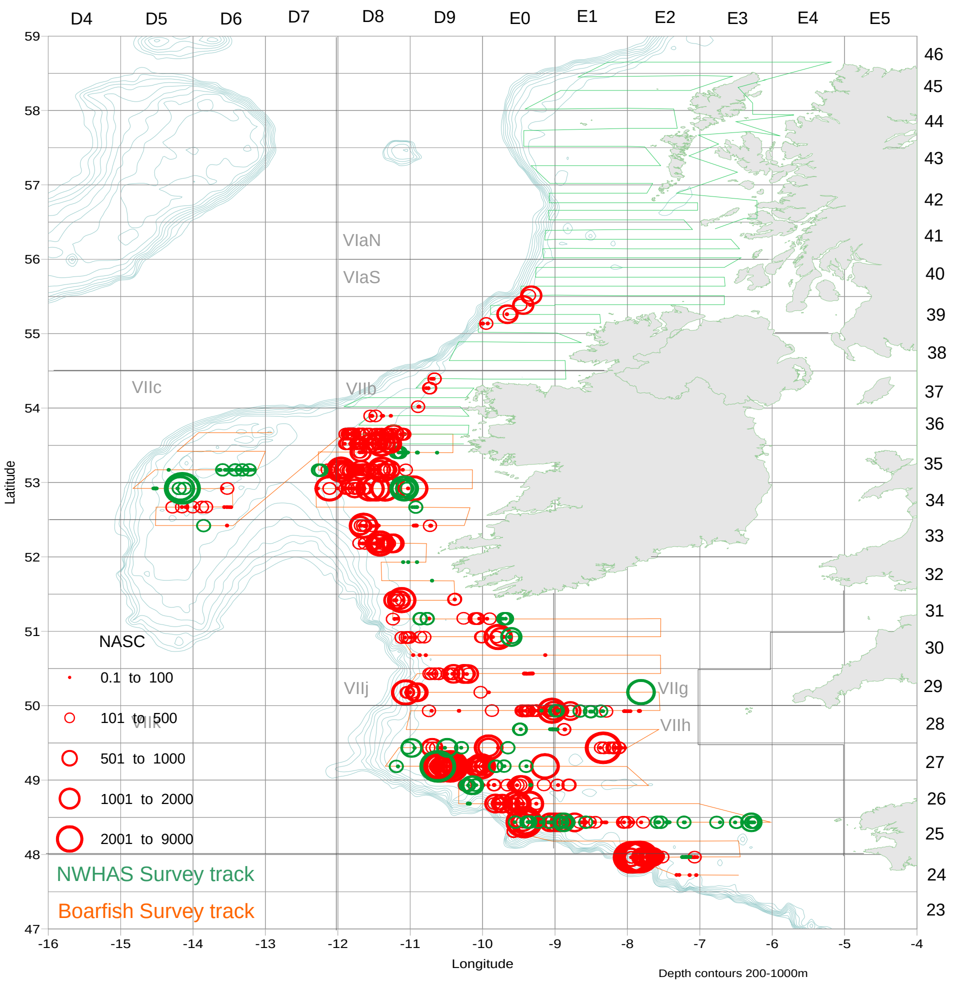


Figure 2. NASC plot of boarfish distribution. Circle size proportional to NASC value. Red circles represent 'definitely' boarfish category and green 'probably boarfish'.

Table 2. Catch composition and position of hauls undertaken by the MFV *Felucca* (numbers 1-20) and for the Celtic Explorer (17-26).

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target btm (m)	Bulk Catch (Kg)	Boarfish %	Mackerel %	Herring %	H Mack %	Others^ %
1	10.07.11	52 40.23	013 32.96	09:11	310	100	2000.0	97.5	0.7		1.8	
2	11.07.11	53 39.00	011 46.75	08:26	282	70-90	2500.0	95.6	1.4		3.0	
3	11.07.11	53 39.06	011 15.15	11:42	184	0-50	1000.0	29.7	46.6		21.1	2.6
4	12.07.11	53 11.74	010 14.04	11:00	98	0-50	2500.0		0.8			98.2
5	12.07.11	52 55.72	010 34.00	15:19	108	15	1500.0					100.0
6	13.07.11	52 25.26	011 29.55	11:52	150	0-40	1500.0	14.4	48.1		37.4	
7	13.07.11	52 09.78	010 47.52	18:32	119	0-15	150.0					100.0
8	14.07.11	51 25.83	011 13.10	08:35	195	50-90	2500.0	90.9			9.1	
9	14.07.11	51 10.06	008 24.40	20:36	103	30	1500.0			88.8		11.2
10	15.07.11	50 55.60	009 47.65	11:33	122	0-25	500.0	91.2	6.9		3.0	
11	19.07.11	50 26.34	010 14.43	09:46	146	80	2500.0	97.0	0.4		2.6	
12	19.07.11	50 10.72	010 59.13	16:46	237	133	0.0					
13	20.07.11	49 55.29	008 31.02	11:51	130	0-40	500.0		7.7	2.0	17.8	72.6
14	21.07.11	49 26.00	008 08.84	15:10	125	80	2000.0	99.0			1.0	
15	22.07.11	49 26.03	010 48.71	07:51	155	50-70	2000.0		62.4			37.6
16	22.07.11	49 11.86	010 27.05	14:20	137	20-70	4000.0	100.0				
17	23.07.11	48 56.43	009 31.09	07:46	162	60-100	2000.0	100.0				
18	23.07.11	48 40.98	009 43.15	15:52	217	120	2000.0	100.0				
19	24.07.11	48 18.35	009 24.75	19:35	144	100	1500.0					100.0
20	25.07.11	47 57.05	007 34.87	12:47	191	100	1500.0	96.6				3.4
17*	30.06.11	55 45.381	008 49.42	07:25	108	103	1000.0	49.5	10.8	39.7		
19*	01.07.11	55 38.23	009 01.25	08:15	94	84	185.0	66.6	33.4		3.8	
26*	07.07.11	53 31.263	011 32.60	15:46	200	100	1500.0	100.0				

^ Includes non target pelagic/demersal species and other taxa

* Celtic Explorer Survey trawls

3.1.1 Boarfish biomass and abundance

A breakdown of the survey stock structure is summarised by age and length in Table 3 and by strata in Table 4. More detailed results are presented by maturity, biomass, abundance and area in Appendix 1.

Boarfish	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	6,701	374,436	86.4
Probably	1,078	59,148	13.6
Total estimate	**7,779**	**433,584**	100
Possibly	52	2,624	
SSB Estimate			
Definitely	6,673	373,884	86.4
Probably	1,071	58,998	13.6
SSB estimate	**7,744**	**432,882**	100

*Biomass derived using an boarfish TS to L relationship (-65.98dB)

3.1.2 Boarfish distribution

A full breakdown of school categorisation, number and biomass by ICES statistical rectangle is provided in Table 4.

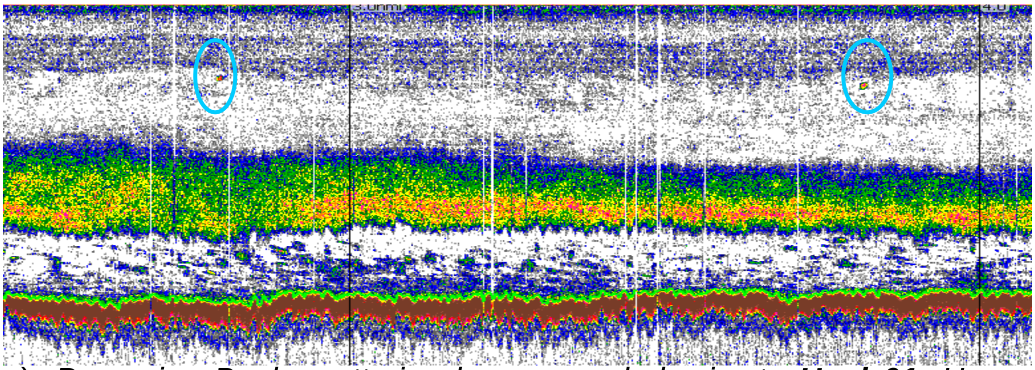
The bulk of the boarfish schools seen on the survey (Figure 2) were located close to the shelf break (200 m contour). This is in contrast to the mainly on shelf distribution of the commercial catches. The commercial fishery for boarfish operates primarily during Q4 and Q1, with some landings during September (end of Q3). From 2007-2010 approximately 20 % of Irish catches have been taken annually in each of two rectangles, 29 E0 and 30 E0 (Figure 2). During the acoustic survey these two rectangles accounted for a relatively small proportion of the total boarfish abundance (Table 4).

Along the west coast high density schools were located high in the water column within the first 50 m subsurface (Figure 3b-c). In southern areas schools were observed closer to the bottom within 30-50 m of the seafloor (Figure 3d-e).

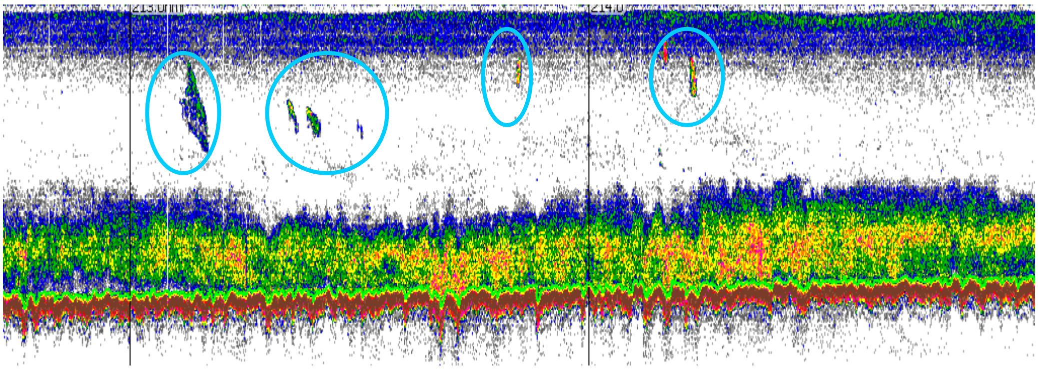
July is the peak of the spawning period as determined from histological analysis of catch samples. It can be inferred from distribution observed during the survey that movements to the shelf edge are part of an annual spawning pattern. During the survey all mature individuals were observed to be spawning i.e. in either a ripe or running state.

Very few immature (< 9.7 cm TL) boarfish were observed during the survey (<0.2 % of TSB) and those encountered formed part of larger aggregations of mature spawning fish at the shelf edge or to a lesser extent as aggregations occurring on shelf. Survey data did not indicate the presence of aggregations of juveniles or potential hotspots of juvenile distribution.

During the survey boarfish Schools were mainly distributed along the shelf edge (Figure 2). These schools were either actively spawning or close to spawning. As a result the abundance estimate is almost exclusively composed of mature individuals (>99 %) which is in contrast to the primarily on-shelf distribution of commercial catches.

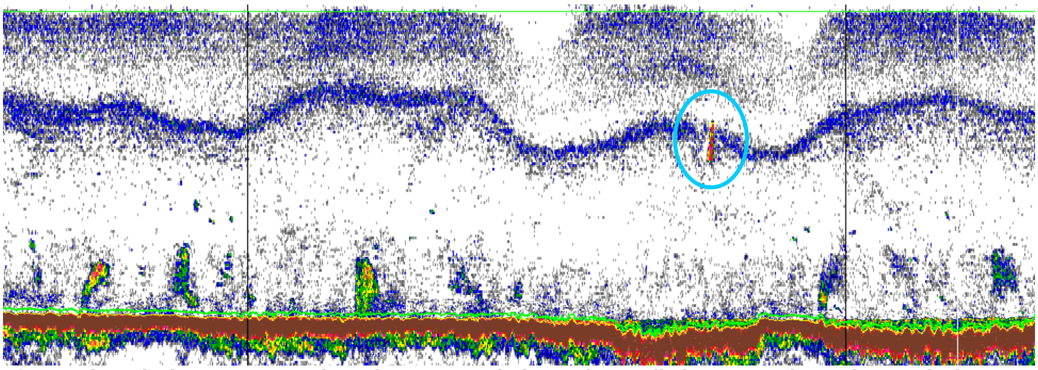


a). *Porcupine Bank scattering layer recorded prior to **Haul 01**. Heavy plankton layer dominates the picture with small high density schools of boarfish occurring above this layer (circled) which were targeted during the trawl. Bottom depth is 300 m with targets occurring at 100 m.*

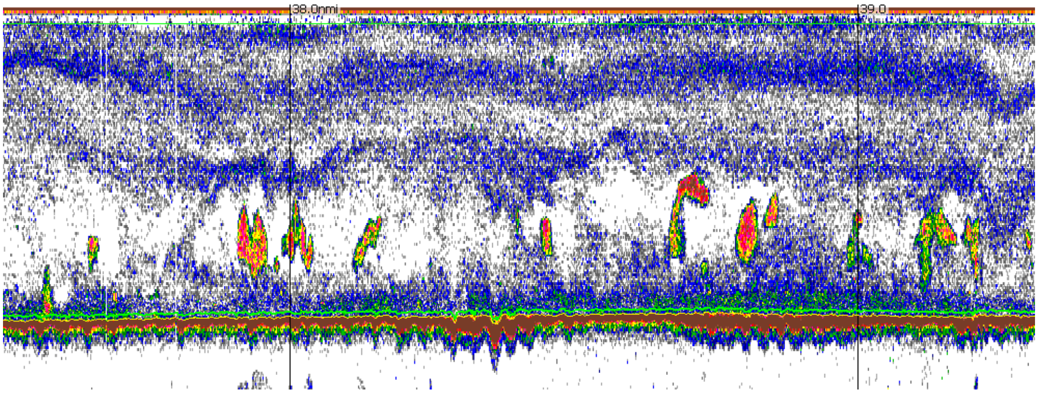


b). *High density bottom feeding layer containing boarfish and mackerel targeted during the trawl (**Haul 03**). Midwater boarfish schools (circled) clearly visible below the thermocline. This type of scattering layer was typical of those encountered between 53º-54º Non shelf in area VIIb. Bottom depth is 184 m with targets extending from 0-50 m off the bottom.*

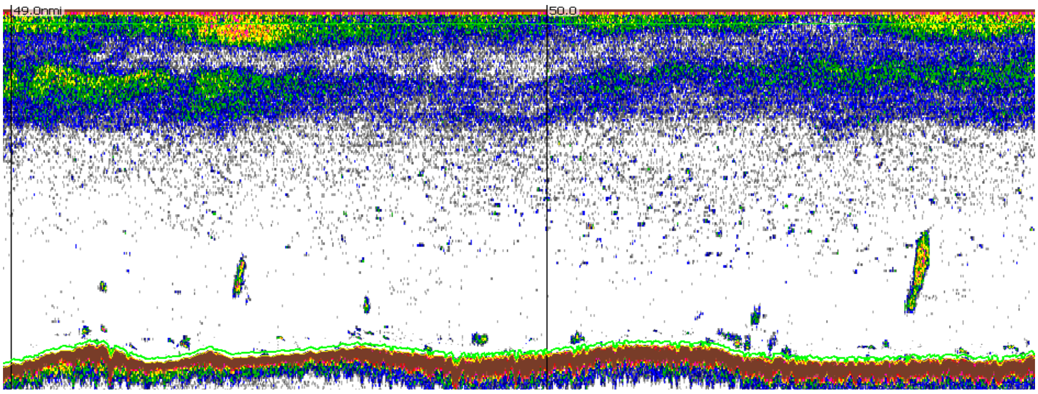
Figures 3a-c. Echotraces recorded prior to directed trawls. Note: vertical bands on echograms represent 1nmi (nautical mile) intervals recorded at 38 kHz.



c). *Mixed bottom schools containing boarfish, mackerel and horse mackerel targeted during* ***Haul 06****. High density boarfish school present midwater (circled). Bottom depth is 150 m with schools extending from 0-40 m off the bottom.*



d). *High-density midwater boarfish schools encountered towards the shelf slope prior to* ***Haul 16*** *in an area of high boarfish abundance. Bottom depth is 137 m with targets occurring 20-70 m off the bottom.*



e). *High-density schools of boarfish close to the bottom, typical of those encountered along the shelf slopes south of 49ºN. Recorded prior to* ***Haul 20****, bottom depth is 191 m with targets occurring 30-80 m off the bottom.*

Figures 3a-d. continued.

3.1.3 Boarfish stock structure

An age length key compiled primarily from commercial samples collected during 2010 was applied during the analysis of survey data (Hussy *et al.* 2012). This ALK was used in place of a survey derived ALK due to the unavailability of aged samples during the analysis. The ALK is considered comprehensive covering a wide range of lengths (2.5-18 cm) including those encountered during this survey (7.5-17.5 cm).

Age distribution as determined from survey samples indicate that the stock is dominated by the following age classes in terms of abundance: 6, 7, 20+ and 9 year old fish and 20+, 9, 7 and 10 years in terms of biomass respectively (Figure 4). Immature fish from 0-2 years were poorly represented in survey catches and this is consistent with a spawning movement of mature stock away from feeding grounds on the shelf. Juveniles are most frequently encountered during the IBTS surveys on the shelf.

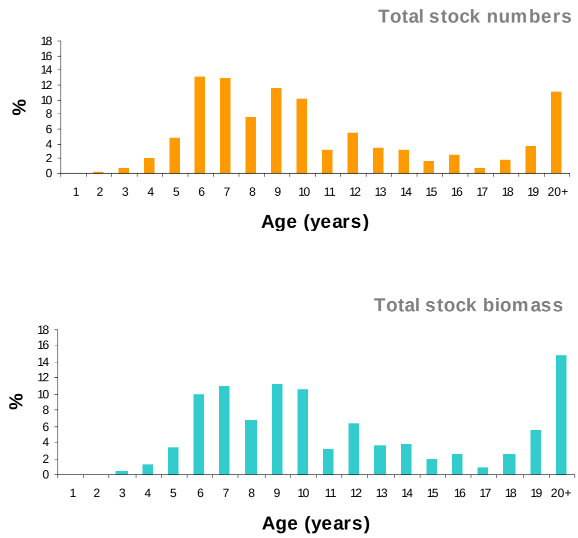


Figure 4. Percentage breakdown of TSN (top) and TSB (bottom) of survey stock.

Table 3. Boarfish length at age (years) as total abundance (millions) and total biomass (000's tonnes).

Length (cm)	Age 1	(years) 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	Abundance (millions)	Biomass (000s t)
4.5																						
5																						
5.5																						
6																						
6.5																						
7																						
7.5	4.7	3.5																			8.2	0.1
8		0.1	0.0																		0.2	
8.5																						
9																						
9.5		4.2	15.4	8.4																	27.9	0.6
10		0.7	4.1	11.5	4.7	0.7															21.6	0.5
10.5		2.2	2.2	31.4	22.4	2.2															60.5	1.7
11				32.8	37.8	17.6	5.0														93.2	2.9
11.5			29.8	29.8	119.6	104.9	62.5	15.1													361.8	12.9
12					93.0	434.2	93.0	155.1													775.3	31.1
12.5				53.5	107.1	267.9	428.6		214.4	160.8	53.5										1285.7	57.9
13						187.7	187.7	250.3	250.3	125.1	62.6	62.6	62.6			62.6					1251.2	63.0
13.5							180.8	180.8	120.6	180.8	60.3	60.3	120.6		60.3	60.3			60.3	120.6	1205.6	67.7
14									229.6	174.9	53.0	174.9		53.0		53.0				114.8	853.1	53.1
14.5							42.3		84.6	84.6		84.6	84.6	127.0				84.6		127.0	719.4	49.5
15										47.0				47.0	47.0		47.0	47.0		235.0	470.0	35.7
15.5										17.5	17.5	52.3		17.5		17.5			175.2	69.7	367.3	30.6
16																			58.5	117.0	175.5	16.0
16.5															12.7			12.7		52.2	77.5	7.7
17																	2.7	2.7		18.9	24.3	2.6
17.5																				0.6	0.6	0.1
18																						
18.5																						
19																						
19.5																						
20																						
TSN	4.7	10.7	51.5	167.3	384.7	1015.2	1000.1	601.3	899.4	790.7	246.8	434.6	267.7	244.5	119.9	193.3	49.7	147.0	294.0	855.8	7,778.8	
TSB	0.0	0.2	1.5	5.8	14.7	43.3	47.9	29.5	49.1	45.4	13.7	27.6	15.7	17.1	8.2	11.3	3.9	10.9	23.3	64.3		433.6
SSN	0	4.2	41.2	156.8	381.5	1014.8	1000.0	601.3	899.4	790.7	246.9	434.6	267.7	244.5	119.9	193.4	49.7	147.0	294.0	855.8	7,743.4	
SSB	0	0.1	1.3	5.6	14.6	43.3	47.9	29.5	49.1	45.4	13.7	27.6	15.7	17.1	8.2	11.3	3.9	10.9	23.3	64.3		432.9
Mn wt (g)	10.6	18.9	29.8	34.7	38.2	42.6	47.9	49.1	54.6	57.4	55.5	63.5	58.8	69.8	68.4	58.4	77.6	74.5	79.3	75.1		
Mn L (cm)	7.8	9.3	11	11.6	12	12.5	13	13.1	13.6	13.8	13.7	14.3	13.9	14.8	14.7	13.9	15.4	15.1	15.4	15.1		

Table 4. Boarfish total biomass and total abundance by ICES statistical rectangle.

Category Stratum	No. transects	No. schools	Def schools	Prob schools	% zeros	Def Biomass	Prob Biomass	Biomass (000't)	SSB (000't)	Abundance millions
36D9	1	0	0	0	100	0	0	0	0	0.0
36D8	1	71	71	0	0	29.2	0	29.2	29.2	504.4
36D6	1	0	0	0	100	0	0	0	0	0.0
35D9	2	4	0	4	50	0	0.1	0.1	0.1	1.9
35D8	2	88	77	11	0	26.6	1.7	28.3	28.3	456.2
35D7	2	7	4	3	50	1.1	1.2	2.3	2.3	36.8
35D6	2	27	0	27	50	0	2.3	2.3	2.3	37.1
35D5	2	1	0	1	50	0	0.2	0.2	0.2	3.8
34D9	2	6	1	5	0	3.4	0.6	3.9	3.9	63.6
34D8	2	31	27	4	50	8.7	4.5	13.3	13.3	213.9
34D7	2	6	6	0	50	3.1	0	3.1	3.1	49.9
34D6	2	8	8	0	0	1.5	0	1.5	1.5	24.9
34D5	2	15	6	9	0	1.6	9.5	11.1	11.1	178.4
33D9	2	12	12	0	50	0.8	0	0.8	0.8	14.3
33D8	2	50	50	0	0	19.7	0	19.7	19.7	361.8
33D6	1	2	1	1	0	0.3	0.4	0.7	0.7	11.7
33D5	1	0	0	0	100	0	0	0	0	0.0
32D9	2	2	0	2	0	0	0.1	0.1	0.1	1.0
32D8	2	2	0	2	50	0	0.1	0.1	0.1	1.7
31D9	2	16	12	4	0	4.3	1.5	5.8	5.8	99.2
31D8	2	15	15	0	0	13.3	0	13.3	13.3	244.3
30D9	2	9	9	0	0	1.9	0	1.9	1.9	33.4
30D8	1	4	4	0	0	5.5	0	5.5	5.5	100.7
29D9	2	27	27	0	0	9.5	0	9.5	9.5	178.8
29D8	1	6	6	0	0	40.4	0	40.4	40.4	757.7
28D9	2	4	4	0	50	0.8	0	0.8	0.8	14.4
28D8	1	0	0	0	100	0	0	0	0	0.0
27D9	2	59	52	7	0	33	6.4	39.4	39.3	819.8
27D8	2	2	0	2	50	0	0.7	0.7	0.7	14.0
26D9	2	20	4	16	0	1.5	4.6	6.1	6.1	125.3
27E4	0	0	0	0		0	0	0	0	0.0
26E4	0	0	0	0		0	0	0	0	0.0
25E4	0	0	0	0		0	0	0	0	0.0
27E3	0	0	0	0		0	0	0	0	0.0
26E3	0	0	0	0		0	0	0	0	0.0
25E3	2	35	15	20	50	22.7	5.9	28.6	28.6	467.4
31E2	1	0	0	0	100	0	0	0	0	0.0
30E2	2	0	0	0	100	0	0	0	0	0.0
29E2	2	1	0	1	50	0	5.2	5.2	5.2	120.1
28E2	2	5	5	0	50	0.7	0	0.7	0.7	16.2
27E2	1	0	0	0	100	0	0	0	0	0.0
26E2	2	0	0	0	100	0	0	0	0	0.0
25E2	2	26	8	18	50	1.1	1.6	2.6	2.6	45.3
31E1	1	0	0	0	100	0	0	0	0	0.0
30E1	2	0	0	0	100	0	0	0	0	0.0
29E1	2	0	0	0	100	0	0	0	0	0.0
28E1	2	36	17	19	0	3.1	2.1	5.2	5.1	119.6
27E1	2	17	17	0	50	6.6	0	6.6	6.5	150.4
26E1	2	4	4	0	50	0.9	0	0.9	0.9	18.1
25E1	2	38	29	9	50	6.8	4	10.8	10.7	178.0
31E0	1	0	0	0	100	0	0	0	0	0.0
30E0	2	0	0	0	100	0	0	0	0	0.0
29E0	2	0	0	0	100	0	0	0	0	0.0
28E0	2	0	0	0	100	0	0	0	0	0.0
27E0	2	18	11	7	0	6.7	2.1	8.8	8.7	178.5
26E0	2	61	59	2	0	19.5	0.1	19.6	19.6	341.7
25E0	2	21	4	17	0	1.3	3.7	5	5	85.6
24E2	2	68	57	11	50	77.9	0.5	78.4	78.2	1360.6
24E3	2	0	0	0	100	0	0	0	0	0.0
40E0	4	2	2	0	75	0.8	0	0.8	0.8	12.8
39E0	4	10	10	0	25	1.9	0	1.9	1.9	32.2
39D9	2	1	1	0	50	0.2	0	0.2	0.2	3.3
37D9	4	15	15	0	25	1.4	0	1.4	1.4	25.2
36D8	3	125	125	0	0	16.7	0	16.7	16.7	275.1
40E1	1	0	0	0	100	0	0	0	0	0.0
40E2	1	0	0	0	100	0	0	0	0	0.0
39E1	4	0	0	0	100	0	0	0	0	0.0
39E2	1	0	0	0	100	0	0	0	0	0.0
39E3	1	0	0	0	100	0	0	0	0	0.0
38E0	2	0	0	0	100	0	0	0	0	0.0
38E1	2	0	0	0	100	0	0	0	0	0.0
37E0	1	0	0	0	100	0	0	0	0	0.0
37E1	1	0	0	0	100	0	0	0	0	0.0
Total	137	977	775	202	53	374.4	59.1	434	432.9	7,778.9
Cv (%)	-	-	-	-	-	-	-	17.6	NA	17.5

3.2 Other pelagics

3.2.1 Herring

Few herring echotraces were observed during the survey and only two trawl samples yielded herring in the Celtic Sea (Table 2). No biomass or abundance calculation was made for this species.

A total of 357 herring were measured and 109 length and weights were recorded. The modal length of herring was 24.5 cm (range 15.5-29.5 cm) and mean weight was 123 g.

The distribution of the herring catches and registrations in the Celtic Sea is consistent with the distribution of summer feeding aggregations as determined from catch data (Haul 9, Table 2). The occurrence of a small amount of herring south of 50° N (haul 13, Table 2) is unusual this far south. The survey track covered areas which are known summer feeding grounds of the Celtic Sea stock, for example around the Kinsale gas rigs and Labadie Bank, but no large shoals were encountered. The absence of large feeding aggregations was considered unusual considering the current size of the stock and maybe accounted for by the unusual hydrographic conditions reported in the Celtic Sea (Van Der Kooij, *pers communication*).

3.2.2 Horse mackerel

Horse mackerel were encountered in 50 % of survey hauls and were most frequently encountered in deeper waters often where boarfish were encountered, (>80 m) Table 2. No biomass or abundance calculation was made for this species.

A total of 542 horse mackerel were measured and 341 length and weights were recorded. The modal length of horse mackerel was 30 cm (range 18-39 cm) and mean weight was 233 g.

Horse mackerel registrations were widely spaced and in general in low density with the exception of 2 areas; one off the southwest coast of Ireland where two Dutch pelagic freezer trawlers reported moderate but consistent catches over several weeks and another area on the shelf edge north of 48° N an area associated with the horse mackerel fishery by Irish and Dutch vessels.

3.2.3 Mackerel

Mackerel were encountered in 9 of 20 trawls (Table 2). No calculation of biomass or abundance was made as reliable acoustically derived estimates of mackerel abundance are not possible due to the low TS-length relationship. Mackerel during the summer feeding phase are less likely to form dense schools and are difficult to differentiate from other acoustic backscatter.

A total of 439 mackerel were measured and 265 length and weights were recorded. The modal lengths of mackerel occurred at 12 cm and 34 cm (range 11-40 cm) and mean weight was 209 g.

The distribution of the mackerel was widespread ranging from shelf seas to the shelf edge. Three hauls yielded high numbers of juvenile 0-group mackerel (11-13 cm) and haul 15 in particular (Table 2) occurred in an area of high 0-group mackerel abundance as determined from similar echotraces observed in the surrounding. Large mature individuals were encountered in the trawl hauls throughout the survey area as would be expected at this time during the feeding phase.

4 Discussion and Conclusions

4.1 Discussion

Overall, the survey can be considered as having been a success with all components of the work program completed as planned. A total of 97 hours was lost due to weather, mechanical and technical issues. The cruise track was adapted at sea to account for real time observations with tracks continuing westward until no further schools were observed. Easterly extension in the mid and southern Celtic Sea was reduced to 07° 30’W and 06° W respectively and effort was reallocated further south following the shelf edge, where the bulk of the stock was located.

The difference between the survey data and the fishery data regarding distribution most likely indicates seasonal spawning movements of boarfish from shelf seas to the shelf edge. The distribution of acoustic densities shows two main areas of concentration; one localised in the west of Ireland and another area stretching along the shelf edge in the southern Celtic Sea. Within these two areas clusters of numerous high density schools dominated. Outside of these areas boarfish were widely distributed and occurred mainly as numerous small schools of mixed medium and high density.

Along the west coast high density schools were located high in the water column within the first 50 m subsurface. In southern areas schools were observed closer to the bottom within 30-50 m of the seafloor. This may be related to hydrographic conditions along the western seaboard. Sea surface temperatures along the west coast as determined from moored weather buoys were in the order of 1.5 °C lower than mean July temperatures and some of the lowest recorded at this time since buoy deployment in 2003 (Lyons *pers communication*). Waters along the west coast during this period were also described as weakly stratified. In the southern Celtic Sea, sea surface temperatures were again lower than average but most interestingly the depth of the thermocline increased greatly towards the shelf edge (Van Der Kooij, *pers communication*). This may account for the distribution of schools closer to the seabed in the southern areas. As boarfish are considered a southerly species that have extended their distribution northwards in recent years their distribution may be limited by preferred temperature.

Daylight hours were the most optimal for acoustic surveying due to the position of high density monospecific schools in the water column which were distinct from the dense plankton layer. During the hours of darkness schools were not as easily seen having dissipated and migrated towards the seabed forming loose mixed species scattering layers. As a result acoustic detection was not considered as effective at night and so a daylight hour’s only survey should be considered in the future. The day/night effect in terms of biomass detection was not considered to be substantial as core areas were covered predominantly during daylight hours. However, no analysis was carried out to quantify the difference observed between day/night observations.

The stock was considered to be sufficiently well contained within the survey area. Communications with IFREMER scientists who carry out their annual PELGAS acoustic survey in the Bay of Biscay (mid May to mid June) reported only a single occurrence of boarfish on the shelf edge at 47° N. Geographical overlap was therefore achieved but with a temporal gap of over one month. A CEFAS acoustic survey in the Celtic Sea and Western approaches in mid June (48-5° N) also observed high density aggregations of boarfish along the shelf edge south around 50° N which is in agreement with our observations (van der Kooij, 2011).

4.2 Conclusions

Acoustically derived estimates of abundance are used as a relative index of abundance of the SSB present within the survey area at the time of surveying. The survey therefore acts as a 'snapshot' of the stock and should not be considered as a measure of absolute stock abundance due to limitations in survey methodology. Such limitations include the precision of the TS-length relationship, echotrace scrutiny and the availability of fish to the acoustic equipment which are inherent in all acoustically derived estimates of abundance. The use of an abundance index allows for the percentage change between successive estimates to be tracked over time to reveal trends in stock abundance as the time series develops. This survey should therefore be treated as the first point in the development of a time series.

Biological samples collected during the survey were used to determine a model based TS-length relationship specific for boarfish. X-ray analysis of trawl caught survey samples revealed the internal integrity of individual swimbladders to be intact and the samples were then scanned using MRI techniques. Swimbladder structure was then modelled to produce a model based TS –length relationship using established methods (Fassler *et al.* 2009). The resulting TS relationship was retrospectively applied to acoustic data presented here. The TS and modelling exercise results are as yet unpublished but is considered as a viable candidate as an acceptable species specific boarfish TS.

4.3 Recommendations

The following recommendations are based on observations made during the survey and are provided as a means of improving the precision of future surveys.

- Boarfish detection by acoustic means at night is not considered as effective as during daylight hours and therefore future surveys should be conducted during daylight hours (04:00-23:00). A similar approach is currently used for herring surveys at this time of year.

- The use of a commercial sized trawl and brailer for routine survey sampling is not necessary and can in fact be limiting in terms of sample quality. It is recommended that a dedicated survey trawl be used or that a smaller brailer, for example a sprat brailer is used for future surveys to ensure the quality of samples.
- The timing of the survey should continue to be aligned with the northwest herring survey to extend the area coverage in the northern area and ensure northern containment of the stock.

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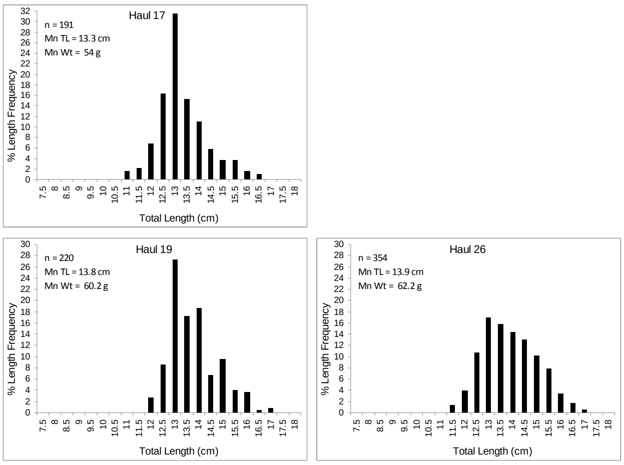
Appendix 1

Table 1. Age length key compiled from commercial catch samples collected during 2010 (Hussy *et al*. 2011). This ALK was applied to boarfish samples collected during the survey.

Length	Age (years)																			
(cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
4.5																				
5																				
5.5																				
6																				
6.5	0.75	0.25																		
7	0.63	0.38																		
7.5	0.57	0.43																		
8		0.83	0.17																	
8.5		0.74	0.26																	
9	0.06	0.39	0.50	0.06																
9.5		0.15	0.55	0.30																
10		0.03	0.19	0.53	0.22	0.03														
10.5		0.04	0.04	0.52	0.37	0.04														
11				0.35	0.41	0.19	0.05													
11.5			0.08	0.08	0.33	0.29	0.17	0.04												
12					0.12	0.56	0.12	0.20												
12.5				0.04	0.08	0.21	0.33		0.17	0.13	0.04									
13						0.15	0.15	0.20	0.20	0.10	0.05	0.05	0.05			0.05				
13.5							0.15	0.15	0.10	0.15	0.05	0.05	0.10		0.05	0.05			0.05	0.10
14									0.26	0.20	0.06	0.20		0.06		0.06				0.13
14.5							0.06		0.12	0.12		0.12	0.12	0.18				0.12		0.18
15										0.10				0.10	0.10		0.10	0.10		0.50
15.5										0.08	0.08	0.25		0.08		0.08			0.08	0.33
16																			0.33	0.67
16.5															0.16			0.16		0.67
17																	0.11	0.11		0.78
17.5																				1.00
18																				1.00
18.5																				
19																				
19.5																				
20																				

Celtic Explorer Hauls



Boarfish Survey Hauls

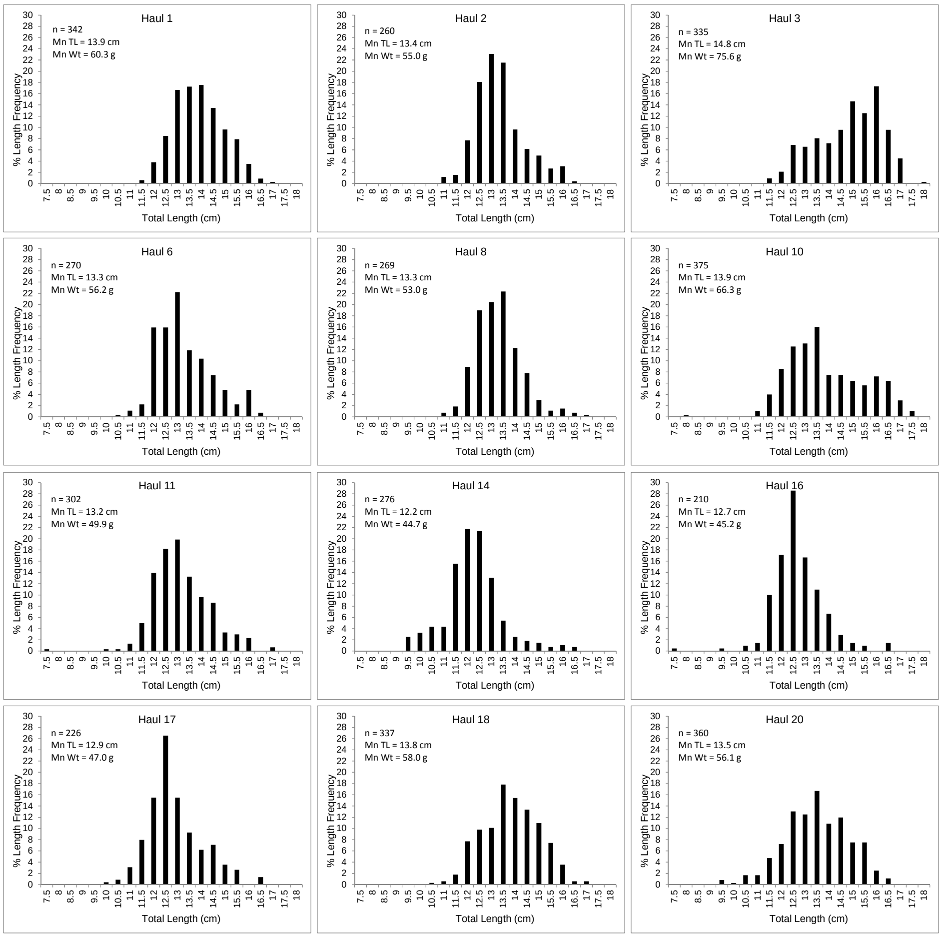


Figure 1. Percentage composition of boarfish by haul presented from north (58° N) to south (47° N).

Table 2. Boarfish total biomass (000's tonnes) at age (years) by ICES statistical rectangle.

Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	Total
36D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36D8	0	0	0	0.2	0.6	2.3	3.1	2.1	3.5	3.2	1	1.9	1.2	1.1	0.6	0.9	0.3	0.7	1.7	4.7	29.2
36D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
35D8	0	0	0	0.1	0.3	1.5	2.3	1.5	3.1	3.1	0.9	2.1	1.1	1.5	0.7	0.8	0.4	1	2.1	5.7	28.3
35D7	0	0	0	0	0	0.1	0.2	0.1	0.3	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0	0.1	0.2	0.5	2.3
35D6	0	0	0	0	0	0.1	0.2	0.1	0.3	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0	0.1	0.2	0.4	2.3
35D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
34D9	0	0	0	0	0	0.2	0.3	0.2	0.4	0.4	0.1	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.8	3.9
34D8	0	0	0	0.1	0.2	0.7	1.1	0.7	1.5	1.4	0.4	1	0.5	0.7	0.3	0.4	0.2	0.5	1	2.7	13.3
34D7	0	0	0	0	0	0.2	0.3	0.2	0.3	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0	0.1	0.2	0.6	3.1
34D6	0	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0	0	0	0	0.1	0.3	1.5
34D5	0	0	0	0	0.1	0.5	0.8	0.6	1.3	1.3	0.4	0.9	0.4	0.6	0.2	0.3	0.1	0.4	0.8	2.1	11.1
33D9	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0.1	0.8
33D8	0	0	0	0.2	0.5	2	2.6	1.7	2.7	2.3	0.7	1.3	0.9	0.6	0.4	0.6	0.1	0.4	0.6	2.3	19.7
33D6	0	0	0	0	0	0	0.1	0	0.1	0.1	0	0.1	0	0	0	0	0	0	0.1	0.1	0.7
33D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
32D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
31D9	0	0	0	0	0.1	0.5	0.6	0.4	0.6	0.6	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.3	1.2	5.8
31D8	0	0	0	0.1	0.4	1.4	1.7	1.1	1.8	1.6	0.5	0.8	0.6	0.4	0.2	0.4	0.1	0.3	0.4	1.5	13.3
30D9	0	0	0	0	0.1	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0	0.1	0	0	0.1	0.3	1.9
30D8	0	0	0	0	0.1	0.6	0.7	0.5	0.7	0.6	0.2	0.3	0.2	0.2	0.1	0.2	0	0.1	0.2	0.6	5.5
29D9	0	0	0	0.1	0.4	1.2	1.2	0.8	1.1	1	0.3	0.6	0.3	0.3	0.1	0.2	0.1	0.2	0.4	1.1	9.5
29D8	0	0	0.1	0.5	1.6	5.2	5.1	3.3	4.9	4.1	1.3	2.4	1.5	1.4	0.5	1	0.3	0.8	1.7	4.8	40.4
28D9	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0.1	0.8
28D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27D9	0	0	0.3	0.9	2.7	7.3	6.6	3.4	4.7	3.8	1.3	1.6	1	0.6	0.5	0.8	0.1	0.5	0.6	2.6	39.4
27D8	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0.7
26D9	0	0	0	0.1	0.4	1.1	1	0.5	0.7	0.6	0.2	0.3	0.2	0.1	0.1	0.1	0	0.1	0.1	0.4	6.1
27E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25E3	0	0	0	0.2	0.5	1.7	2.2	1.5	3	3.1	0.9	2.2	1.1	1.6	0.7	0.8	0.4	1	2.1	5.8	28.6
31E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29E2	0	0	0.1	0.3	0.6	1.2	0.8	0.4	0.5	0.4	0.1	0.1	0.1	0.1	0	0.1	0	0	0.1	0.3	5.2
28E2	0	0	0	0	0.1	0.2	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0.7
27E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25E2	0	0	0	0	0.1	0.2	0.2	0.1	0.3	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0	0.1	0.2	0.4	2.6
31E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28E1	0	0	0.1	0.3	0.6	1.2	0.8	0.4	0.5	0.4	0.1	0.1	0.1	0.1	0	0.1	0	0	0.1	0.3	5.2
27E1	0	0	0.1	0.4	0.7	1.5	1	0.6	0.6	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0	0.1	0.1	0.4	6.6
26E1	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0.1	0.9
25E1	0	0	0	0.1	0.2	0.7	0.9	0.6	1.1	1.2	0.3	0.8	0.4	0.6	0.2	0.3	0.1	0.4	0.8	2.1	10.8
31E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27E0	0	0	0.1	0.2	0.6	1.5	1.4	0.7	1	0.8	0.3	0.4	0.2	0.2	0.1	0.2	0	0.1	0.2	0.7	8.8
26E0	0	0	0	0.2	0.6	1.8	2	1.1	2.1	2.1	0.6	1.3	0.7	0.9	0.4	0.5	0.2	0.6	1.2	3.3	19.6
25E0	0	0	0	0.1	0.1	0.4	0.5	0.3	0.5	0.5	0.2	0.4	0.2	0.2	0.1	0.1	0.1	0.2	0.4	0.9	5
24E2	0	0.1	0.4	1.2	2.4	6	7.4	4.5	8.1	8.1	2.4	5.5	3	3.7	1.7	2	0.8	2.3	5.7	13	78.4
24E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40E0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0.1	0	0	0	0	0	0	0	0.1	0.8
39E0	0	0	0	0	0	0.1	0.2	0.1	0.3	0.2	0.1	0.1	0.1	0.1	0	0.1	0	0	0.1	0.4	1.9
39D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
37D9	0	0	0	0	0	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0	0	0	0	0	0.1	0.2	1.4
36D8	0	0	0	0.1	0.2	1	1.5	1	1.9	1.8	0.5	1.2	0.6	0.8	0.4	0.5	0.2	0.5	1.2	3.2	16.7
40E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0.2	1.5	5.8	14.7	43.3	47.9	29.5	49.1	45.4	13.7	27.6	15.7	17.1	8.2	11.3	3.9	10.9	23.3	64.3	433.6
%	0	0	0.4	1.3	3.4	10	11.1	6.8	11.3	10.5	3.2	6.4	3.6	3.9	1.9	2.6	0.9	2.5	5.4	14.8	100

Table 3. Boarfish total abundance (millions) at age (years) by ICES statistical rectangle.

Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	Total
36D9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36D8	0.0	0.0	0.6	5.1	14.1	52.2	63.8	42.1	64.2	56.4	18.0	30.6	20.2	16.1	9.1	14.8	3.7	9.6	21.6	62.2	504.4
36D6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35D9	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.3	1.9
35D8	0.0	0.0	0.5	2.6	8.4	33.8	45.5	30.2	55.5	51.5	15.3	33.1	18.1	20.9	9.5	13.3	4.9	13.2	26.0	74.1	456.2
35D7	0.0	0.0	0.0	0.2	0.7	2.7	3.7	2.4	4.5	4.2	1.2	2.7	1.5	1.7	0.8	1.1	0.4	1.1	2.1	6.0	36.8
35D6	0.0	0.0	0.0	0.1	0.5	2.4	3.4	2.5	4.7	4.4	1.3	3.0	1.5	1.8	0.7	1.2	0.4	1.0	2.2	5.9	37.1
35D5	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.3	0.5	0.5	0.1	0.3	0.2	0.2	0.1	0.1	0.0	0.1	0.2	0.6	3.8
34D9	0.0	0.0	0.1	0.4	1.2	4.7	6.3	4.2	7.7	7.2	2.1	4.6	2.5	2.9	1.3	1.9	0.7	1.8	3.6	10.3	63.6
34D8	0.0	0.0	0.2	1.2	3.9	15.8	21.3	14.1	26.0	24.1	7.2	15.5	8.5	9.8	4.5	6.2	2.3	6.2	12.2	34.7	213.9
34D7	0.0	0.0	0.1	0.3	0.9	3.7	5.0	3.3	6.1	5.6	1.7	3.6	2.0	2.3	1.0	1.5	0.5	1.4	2.8	8.1	49.9
34D6	0.0	0.0	0.0	0.1	0.3	1.6	2.3	1.7	3.2	2.9	0.9	2.0	1.0	1.2	0.5	0.8	0.2	0.7	1.4	4.0	24.9
34D5	0.0	0.0	0.1	0.7	2.4	11.7	16.5	12.0	22.8	21.1	6.3	14.3	7.4	8.6	3.5	5.6	1.8	4.9	10.3	28.4	178.4
33D9	0.0	0.0	0.0	0.2	0.5	1.8	2.1	1.3	2.0	1.7	0.5	0.8	0.6	0.4	0.2	0.4	0.0	0.2	0.3	1.3	14.3
33D8	0.0	0.0	0.6	4.4	12.9	45.9	52.9	33.6	49.6	41.8	13.5	20.7	15.1	9.0	5.6	10.7	1.2	5.0	7.8	31.6	361.8
33D6	0.0	0.0	0.0	0.0	0.2	0.8	1.1	0.8	1.5	1.4	0.4	0.9	0.5	0.6	0.2	0.4	0.1	0.3	0.7	1.9	11.7
33D5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32D9	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0
32D8	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.2	1.7
31D9	0.0	0.1	0.3	1.2	3.7	11.6	12.6	8.0	11.4	10.0	3.2	5.2	3.6	2.6	2.0	2.6	0.6	2.1	3.9	14.5	99.2
31D8	0.0	0.0	0.4	2.9	8.7	31.0	35.7	22.7	33.5	28.2	9.1	14.0	10.2	6.1	3.7	7.2	0.8	3.4	5.2	21.4	244.3
30D9	0.0	0.0	0.1	0.4	1.3	4.2	4.5	2.9	4.0	3.5	1.1	1.8	1.2	0.9	0.6	0.9	0.2	0.6	1.1	4.1	33.4
30D8	0.0	0.0	0.2	1.2	3.6	12.8	14.7	9.4	13.8	11.6	3.8	5.8	4.2	2.5	1.5	3.0	0.3	1.4	2.2	8.8	100.7
29D9	0.3	0.3	0.9	3.5	9.9	29.1	25.3	16.0	21.3	17.4	5.6	9.1	6.0	4.6	1.8	4.3	0.7	2.5	5.1	15.1	178.8
29D8	1.4	1.2	3.7	15.0	42.1	123.3	107.2	67.8	90.4	73.5	23.9	38.3	25.2	19.6	7.5	18.1	3.1	10.7	21.6	63.8	757.7
28D9	0.0	0.0	0.1	0.3	0.8	2.3	2.0	1.3	1.7	1.4	0.5	0.7	0.5	0.4	0.1	0.3	0.1	0.2	0.4	1.2	14.4
28D8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27D9	2.2	2.5	9.2	25.8	71.1	174.3	145.1	72.3	92.8	71.9	24.8	26.4	18.6	9.1	7.6	15.1	1.2	5.8	8.2	35.7	819.8
27D8	0.0	0.0	0.2	0.4	1.2	3.0	2.5	1.2	1.6	1.2	0.4	0.5	0.3	0.2	0.1	0.3	0.0	0.1	0.1	0.6	14.0
26D9	0.3	0.4	1.4	3.8	10.5	25.9	21.7	10.9	14.2	11.1	3.8	4.2	2.9	1.6	1.2	2.4	0.2	1.0	1.5	6.1	125.3
27E4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26E4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25E4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27E3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26E3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25E3	0.0	0.1	0.7	4.3	12.5	39.8	44.4	29.5	52.1	51.8	14.6	33.6	18.0	22.3	9.7	12.7	5.4	13.2	26.2	76.4	467.4
31E2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30E2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29E2	0.0	0.8	4.1	10.1	16.4	29.1	18.7	10.1	9.1	6.9	2.4	2.1	1.7	0.8	0.6	1.3	0.2	0.6	1.2	3.9	120.1
28E2	0.0	0.1	0.6	1.4	2.2	3.9	2.5	1.4	1.2	0.9	0.3	0.3	0.2	0.1	0.1	0.2	0.0	0.1	0.2	0.5	16.2
27E2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26E2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25E2	0.0	0.1	0.4	1.3	2.2	4.7	5.1	3.0	4.8	4.6	1.4	2.8	1.7	1.8	0.8	1.1	0.3	1.1	2.4	5.8	45.3
31E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28E1	0.0	0.8	4.1	10.1	16.3	28.9	18.6	10.1	9.1	6.8	2.4	2.1	1.7	0.8	0.6	1.3	0.2	0.6	1.2	3.9	119.6
27E1	0.0	1.0	5.2	12.7	20.5	36.4	23.4	12.7	11.5	8.6	3.0	2.6	2.1	1.0	0.8	1.7	0.2	0.7	1.5	4.9	150.4
26E1	0.0	0.0	0.1	0.6	1.5	3.5	3.0	1.4	2.0	1.6	0.5	0.7	0.5	0.4	0.2	0.3	0.1	0.3	0.3	1.1	18.1
25E1	0.0	0.1	0.6	2.4	5.7	15.9	17.6	11.4	19.7	19.3	5.5	12.4	6.8	8.1	3.6	4.7	1.9	4.8	9.8	27.6	178.0
31E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27E0	0.3	0.3	1.7	5.9	15.2	36.5	30.5	15.0	19.9	15.7	5.3	6.2	4.3	2.8	1.7	3.2	0.4	1.8	2.4	9.3	178.5
26E0	0.0	0.1	1.3	6.2	15.9	42.0	40.6	23.4	37.9	35.2	10.3	20.5	11.6	13.2	5.9	8.1	3.0	8.0	14.6	43.9	341.7
25E0	0.0	0.1	0.7	2.0	3.7	8.5	9.2	5.6	9.2	8.9	2.6	5.5	3.2	3.5	1.6	2.2	0.7	2.1	4.6	11.7	85.6
24E2	0.0	2.7	13.1	37.8	66.3	141.4	152.4	90.4	145.1	137.6	41.3	83.7	50.3	52.9	24.0	33.9	10.2	31.8	71.4	174.4	1360.6
24E3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40E0	0.0	0.0	0.0	0.0	0.1	0.9	1.3	1.1	1.8	1.6	0.5	0.9	0.5	0.4	0.2	0.5	0.1	0.2	0.5	1.8	12.8
39E0	0.0	0.0	0.0	0.1	0.3	2.4	3.3	2.8	4.6	3.9	1.3	2.4	1.3	1.1	0.6	1.2	0.3	0.6	1.3	4.6	32.2
39D9	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.5	0.4	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.5	3.3
37D9	0.0	0.0	0.0	0.3	0.8	2.9	3.4	2.3	3.3	2.8	0.9	1.4	1.0	0.7	0.4	0.7	0.1	0.4	0.9	2.7	25.2
36D8	0.0	0.0	0.3	1.9	5.8	22.6	29.4	19.5	33.9	31.0	9.4	19.0	10.9	11.6	5.5	8.0	2.7	7.2	14.6	41.7	275.1
40E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40E2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39E2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39E3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4.7	10.7	51.5	167.3	384.7	1015.2	1000.0	601.3	899.4	790.7	246.8	434.6	267.7	244.5	119.9	193.3	49.7	147.0	294.0	855.8	7779
%	0.1	0.1	0.7	2.2	4.9	13.1	12.9	7.7	11.6	10.2	3.2	5.6	3.4	3.1	1.5	2.5	0.6	1.9	3.8	11.0	100
Cv (%)	35.9	28.7	27.1	23.3	20.8	18.3	17.5	16.8	16.8	17.6	17.6	18.6	17.8	20.3	19.4	17.7	21.1	20.3	22	19.4	NA

Table 4. Boarfish total biomass (000's tonnes) at maturity by ICES statistical rectangle.

Strata	Imm	Mature	Spent	Total
36D9	0	0	0	0
36D8	0	29.2	0	29.2
36D6	0	0	0	0
35D9	0	0.1	0	0.1
35D8	0	28.3	0	28.3
35D7	0	2.3	0	2.3
35D6	0	2.3	0	2.3
35D5	0	0.2	0	0.2
34D9	0	3.9	0	3.9
34D8	0	13.3	0	13.3
34D7	0	3.1	0	3.1
34D6	0	1.5	0	1.5
34D5	0	11.1	0	11.1
33D9	0	0.8	0	0.8
33D8	0	19.7	0	19.7
33D6	0	0.7	0	0.7
33D5	0	0	0	0
32D9	0	0.1	0	0.1
32D8	0	0.1	0	0.1
31D9	0	5.8	0	5.8
31D8	0	13.3	0	13.3
30D9	0	1.9	0	1.9
30D8	0	5.5	0	5.5
29D9	0	9.5	0	9.5
29D8	0	40.4	0	40.4
28D9	0	0.8	0	0.8
28D8	0	0	0	0
27D9	0.1	39.3	0	39.4
27D8	0	0.7	0	0.7
26D9	0	6.1	0	6.1
27E4	0	0	0	0
26E4	0	0	0	0
25E4	0	0	0	0
27E3	0	0	0	0
26E3	0	0	0	0
25E3	0	28.6	0	28.6
31E2	0	0	0	0
30E2	0	0	0	0
29E2	0.1	5.2	0	5.2
28E2	0	0.7	0	0.7
27E2	0	0	0	0
26E2	0	0	0	0
25E2	0	2.6	0	2.6
31E1	0	0	0	0
30E1	0	0	0	0
29E1	0	0	0	0
28E1	0.1	5.1	0	5.2
27E1	0.1	6.5	0	6.6
26E1	0	0.9	0	0.9
25E1	0	10.7	0	10.8
31E0	0	0	0	0
30E0	0	0	0	0
29E0	0	0	0	0
28E0	0	0	0	0
27E0	0	8.7	0	8.8
26E0	0	19.6	0	19.6
25E0	0	5	0	5
24E2	0.2	78.2	0	78.4
24E3	0	0	0	0
40E0	0	0.8	0	0.8
39E0	0	1.9	0	1.9
39D9	0	0.2	0	0.2
37D9	0	1.4	0	1.4
36D8	0	16.7	0	16.7
40E1	0	0	0	0
40E2	0	0	0	0
39E1	0	0	0	0
39E2	0	0	0	0
39E3	0	0	0	0
38E0	0	0	0	0
38E1	0	0	0	0
37E0	0	0	0	0
37E1	0	0	0	0
Total	0.7	432.9	0	434
%	0.2	99.8	0	100

Table 5. Boarfish total abundance (millions) at maturity by ICES statistical rectangle.

Strata	Imm	Mature	Spent	Total
36D9	0.0	0.0	0	0.0
36D8	0.0	504.4	0	504.4
36D6	0.0	0.0	0	0.0
35D9	0.0	1.9	0	1.9
35D8	0.0	456.2	0	456.2
35D7	0.0	36.8	0	36.8
35D6	0.0	37.1	0	37.1
35D5	0.0	3.8	0	3.8
34D9	0.0	63.6	0	63.6
34D8	0.0	213.9	0	213.9
34D7	0.0	49.9	0	49.9
34D6	0.0	24.9	0	24.9
34D5	0.0	178.4	0	178.4
33D9	0.0	14.3	0	14.3
33D8	0.0	361.8	0	361.8
33D6	0.0	11.7	0	11.7
33D5	0.0	0.0	0	0.0
32D9	0.0	1.0	0	1.0
32D8	0.0	1.7	0	1.7
31D9	0.1	99.0	0	99.2
31D8	0.0	244.3	0	244.3
30D9	0.0	33.3	0	33.4
30D8	0.0	100.7	0	100.7
29D9	0.8	178.1	0	178.8
29D8	3.3	754.4	0	757.7
28D9	0.1	14.3	0	14.4
28D8	0.0	0.0	0	0.0
27D9	7.0	812.8	0	819.8
27D8	0.1	13.9	0	14.0
26D9	1.0	124.3	0	125.3
27E4	0.0	0.0	0.0	0.0
26E4	0.0	0.0	0.0	0.0
25E4	0.0	0.0	0.0	0.0
27E3	0.0	0.0	0.0	0.0
26E3	0.0	0.0	0.0	0.0
25E3	0.1	467.2	0	467.4
31E2	0.0	0.0	0	0.0
30E2	0.0	0.0	0	0.0
29E2	3.1	117.0	0	120.1
28E2	0.4	15.8	0	16.2
27E2	0.0	0.0	0	0.0
26E2	0.0	0.0	0	0.0
25E2	0.3	44.9	0	45.3
31E1	0.0	0.0	0	0.0
30E1	0.0	0.0	0	0.0
29E1	0.0	0.0	0	0.0
28E1	3.1	116.5	0	119.6
27E1	3.9	146.5	0	150.4
26E1	0.0	18.0	0	18.1
25E1	0.3	177.7	0	178.0
31E0	0.0	0.0	0	0.0
30E0	0.0	0.0	0	0.0
29E0	0.0	0.0	0	0.0
28E0	0.0	0.0	0	0.0
27E0	1.0	177.5	0	178.5
26E0	0.3	341.4	0	341.7
25E0	0.5	85.1	0	85.6
24E2	9.8	1350.7	0	1360.6
24E3	0.0	0.0	0	0.0
40E0	0.0	12.8	0	12.8
39E0	0.0	32.2	0	32.2
39D9	0.0	3.3	0	3.3
37D9	0.0	25.2	0	25.2
36D8	0.0	275.1	0	275.1
40E1	0.0	0.0	0	0.0
40E2	0.0	0.0	0	0.0
39E1	0.0	0.0	0	0.0
39E2	0.0	0.0	0	0.0
39E3	0.0	0.0	0	0.0
38E0	0.0	0.0	0	0.0
38E1	0.0	0.0	0	0.0
37E0	0.0	0.0	0	0.0
37E1	0.0	0.0	0	0.0
Total	35.4	7,743	0	7,779
%	0.5	99.5	0	100

Appendix 2

Details of the charter vessel and tow body set up used during the survey.

Figure 1. FV *Felucca* (SO 108). Registered length 58 m, beam 11 m and built in 1995.

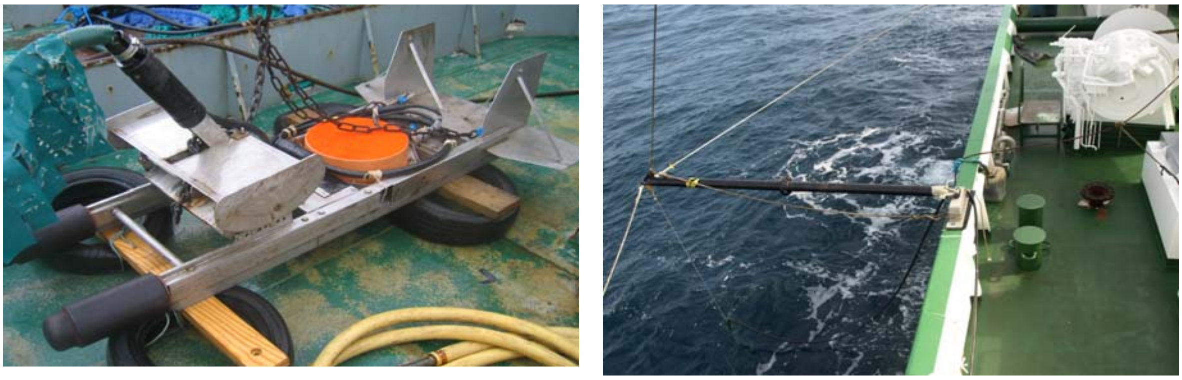


Figure 2. Left panel: Tow sled with 38 kHz split beam transducer (orange centre screen) and right panel: towing boom c3 m long with support stays.

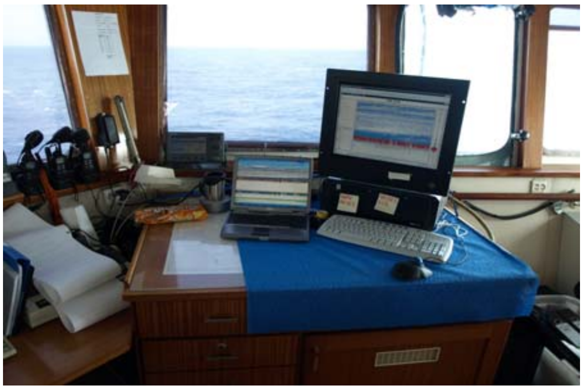


Figure 3. Top side monitoring station located on the bridge. Laptop (left) running Echoview and EK 60 topside PC unit (right).

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